EIC Users Group Meeting 2016:

EIC Computing

Markus Diefenthaler

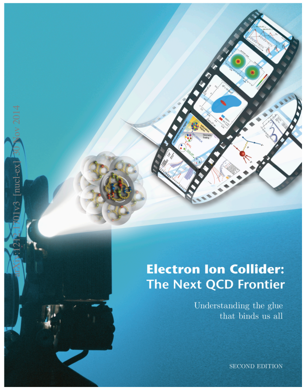
Computing R&D as part of (Detector) R&D

2016

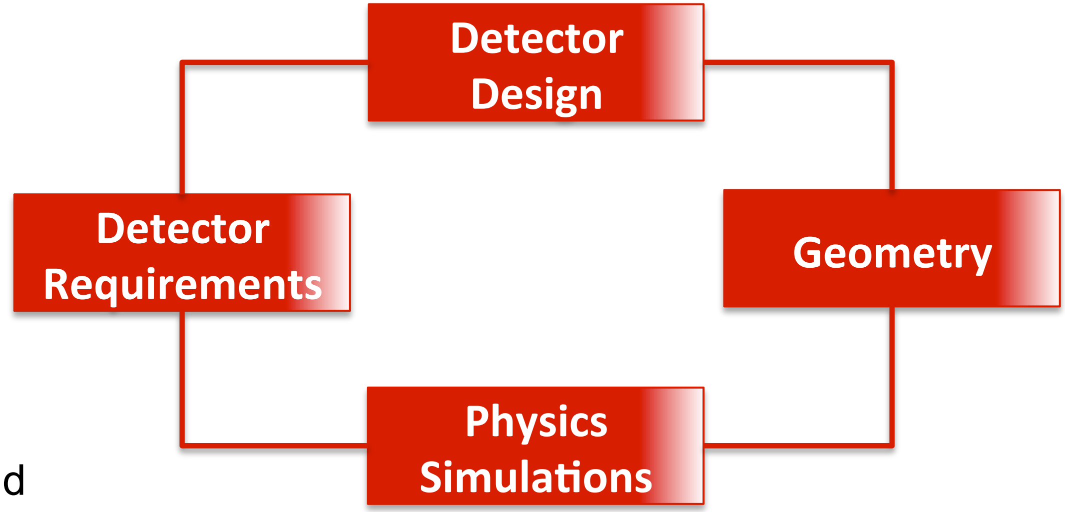
one decade of software development

2025

Detector & Physics Simulations:



+ physics beyond the White Paper



Online & Offline Framework

Towards an active collaboration

Workshops at Jefferson Lab

09/2015: Workshop **EIC Software Meeting**

- **organizers:** Elke-Caroline Aschenauer (BNL), Markus Diefenthaler
- **workshop goals:**
  - review software status with focus on detector and physics simulations
  - identify interfaces between existing BNL and JLab software
  - foster active collaboration
- **website:** https://www.jlab.org/conferences/eicsw/

03/2016: Workshop **Future Trends in NP Computing**

- **organizers:** Amber Boehnlein, Markus Diefenthaler, and Graham Heyes
- **workshop goals:**
  - incubator for computing ideas in the the exascale era
  - identify ways to improve usability of NP Computing
  - identify ways to make new data faster available for physics analysis
  - identify best practices for NP Computing
- **website:** https://www.jlab.org/conferences/trends2016/

EIC Software Meeting (09/2015)

- 36 participants from both BNL (mostly remotely) and Jefferson Lab
- presentations available on https://www.jlab.org/conferences/eicsw/

Thursday, September 24, 2015 (F326/327)		
09:00 - 09:15	Welcome, Meeting goals	Markus Diefenthaler
09:15 - 10:45	**Monte Carlo Generators - Part I**	
09:15 - 10:00	Monte Carlo Generators for EIC	Elke-Caroline Aschenauer
10:00 - 10:30	mPYTHIA - Towards an Event Generator for TMD	Hrayr Matevosyan
10:30 - 10:45	*Coffee Break*	
10:45 - 11:59	**Monte Carlo Generators - Part II**	
10:45 - 11:00	Simulating spectator nucleon tagging with EIC	Christian Weiss
11:00 - 11:30	Forward Spectator Tagging Event Generator	Kijun Park
11:30 - 11:59	Hadron Elecro and Photo Production Generators Overview	Rakitha Beminiwattha
12:00 - 01:00	*Lunch*	
01:00 - 02:15	**Monte Carlo Generators III**	
01:00 - 01:45	Recent developments in Pythia 8	Stefan Prestel
01:45 - 02:15	Discussion about Monte Carlo Generators	
02:15 - 02:30	*Break*	
02:30 - 5:00	**Software Tools**	
02:30 - 03:00	EicRoot software framework	Alexander Kiselev
03:00 - 03:30	GEant4 Monte Carlo	Maurizio Ungaro
03:30 - 04:00	EicRoot for tracking R&D studies	Alexander Kiselev
04:00 - 04:15	*Break*	
04:00 - 05:00	**Discussion on interfaces**	
06:00 - 08:00	*Dinner at Fin SeaFood*	

Friday, September 25, 2015 (L102)		
09:00 - 10:30	**Software Frameworks I**	
09:00 - 09:50	Framework design experience from art	Marc Paterno
09:50 - 10:10	The JANA Design	David Lawrence
10:10 - 10:30	Software design ideas for SoLID	Ole Hansen
10:30 - 10:45	*Coffee Break*	
10:45 - 11:40	**Software Frameworks II, Monte Carlo Generators IV**	
10:45 - 11:10	Fun4all	Christopher Pinkenburg
11:10 - 11:40	TMD Evolution and QCD Theory at An EIC	Ted Rogers
11:40 - 12:10	**Meeting summary and common goals**	
12:10 - 01:00	*Lunch*	

focus on detector & physics simulations:

- MC generators for EIC physics program
- tools for detector simulations
- tracking software
- tools for detector development

Workshop Review of MC generators for EIC

- **MC generators for ep processes:**
  - several excellent MC generators available
  - but essential pieces are missing:
    - MC generator for (un)-polarized p_T dependent physics
    - radiative corrections not integrated in many generators, required as physics and detector smearing don't factorize

LEPTO (DIS)

PEPSI (polarized DIS)

PYTHIA 6

PYTHIA 8

GMC_TRANS (SIDIS)

CASCADE (ep + pp, p_T)

MILOU (DVCS)

DJANGOH (radiative effects)

many more generators

- **MC generators for eA processes:**
  - significantly worse situation than ep
  - need a SIDIS generator w/o saturation
  - need CASCADE like eA generator

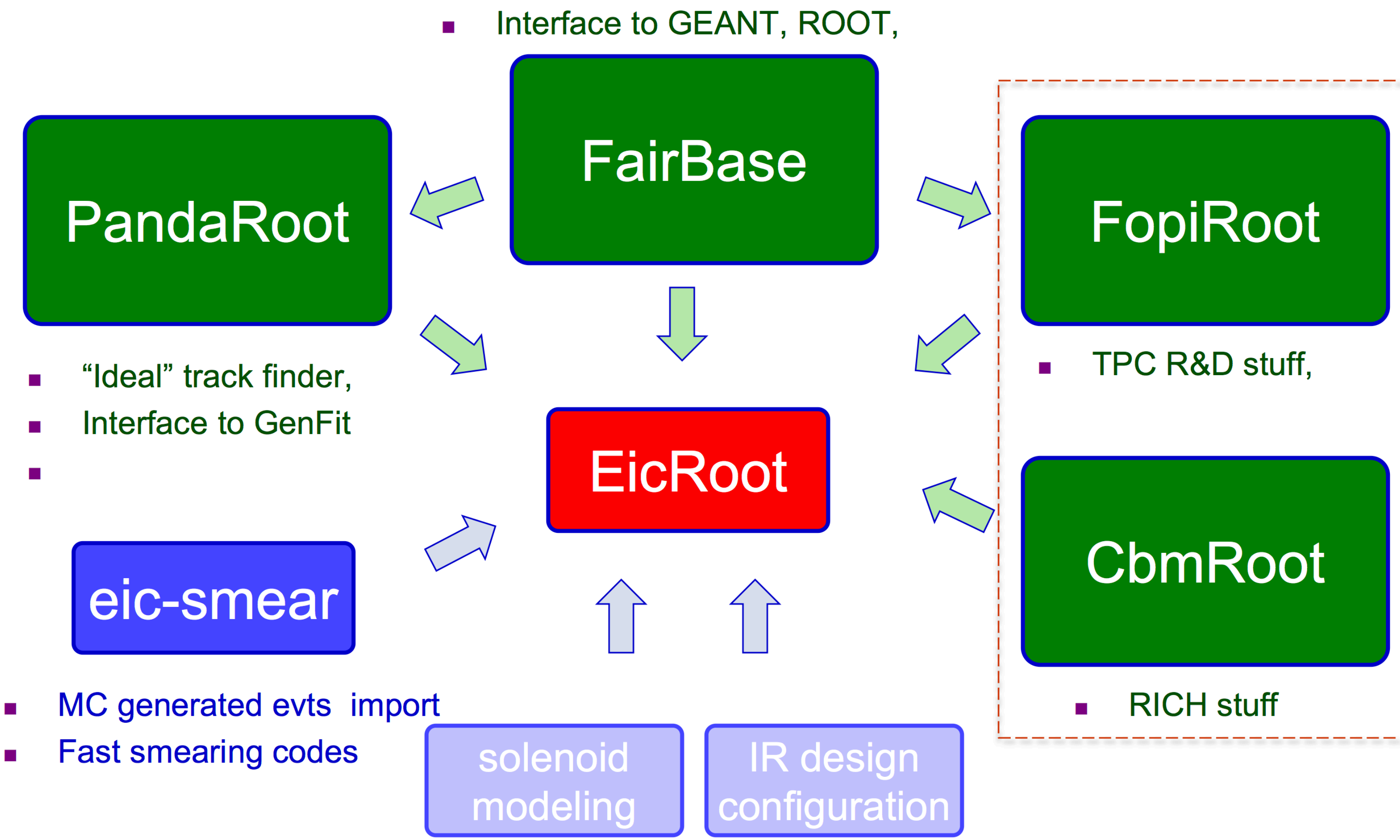
PYTHIA + DPMJET

DJANGOH (radiative effects)

SARTRE (diffractive, DVCS)

EicRoot

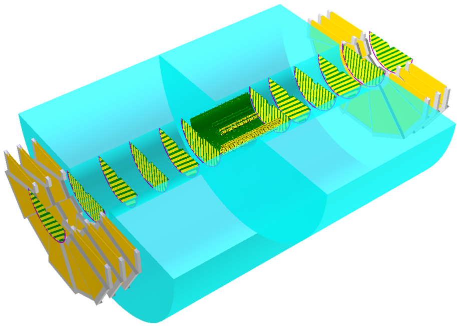
- based on FairRoot, developed by Alexander Kiselev (BNL) for eRHIC
- available for standalone R&D studies

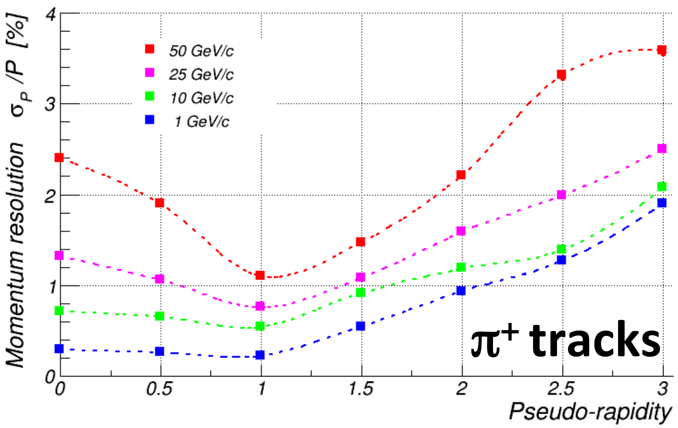


EicRoot Tracking

adapted from other experiments:

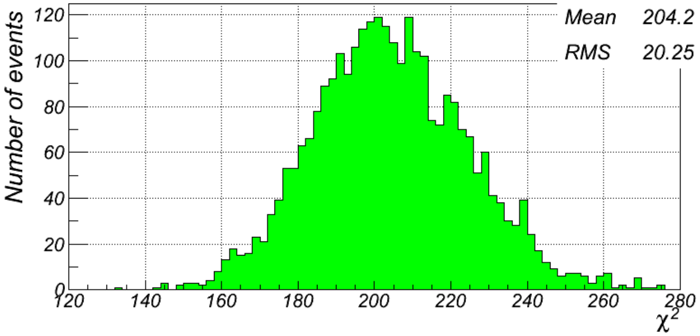
- **PandaRoot**: *ideal* track finder, GenFit fitter, (…)
- **FopiRoot:** TPC digitization, realistic track finders (Hough transform; Riemann sphere fit), GenFit fitter, RAVE vertex builder, (…)
- **HERMES:** linearized Kalman filter



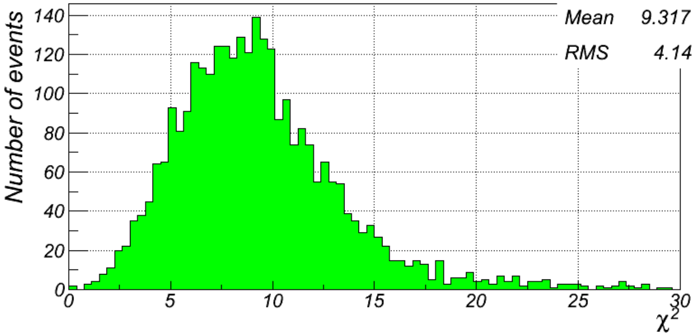


Kalman filter fit quality:

1 GeV π^+ tracks at $\eta=0.5$:

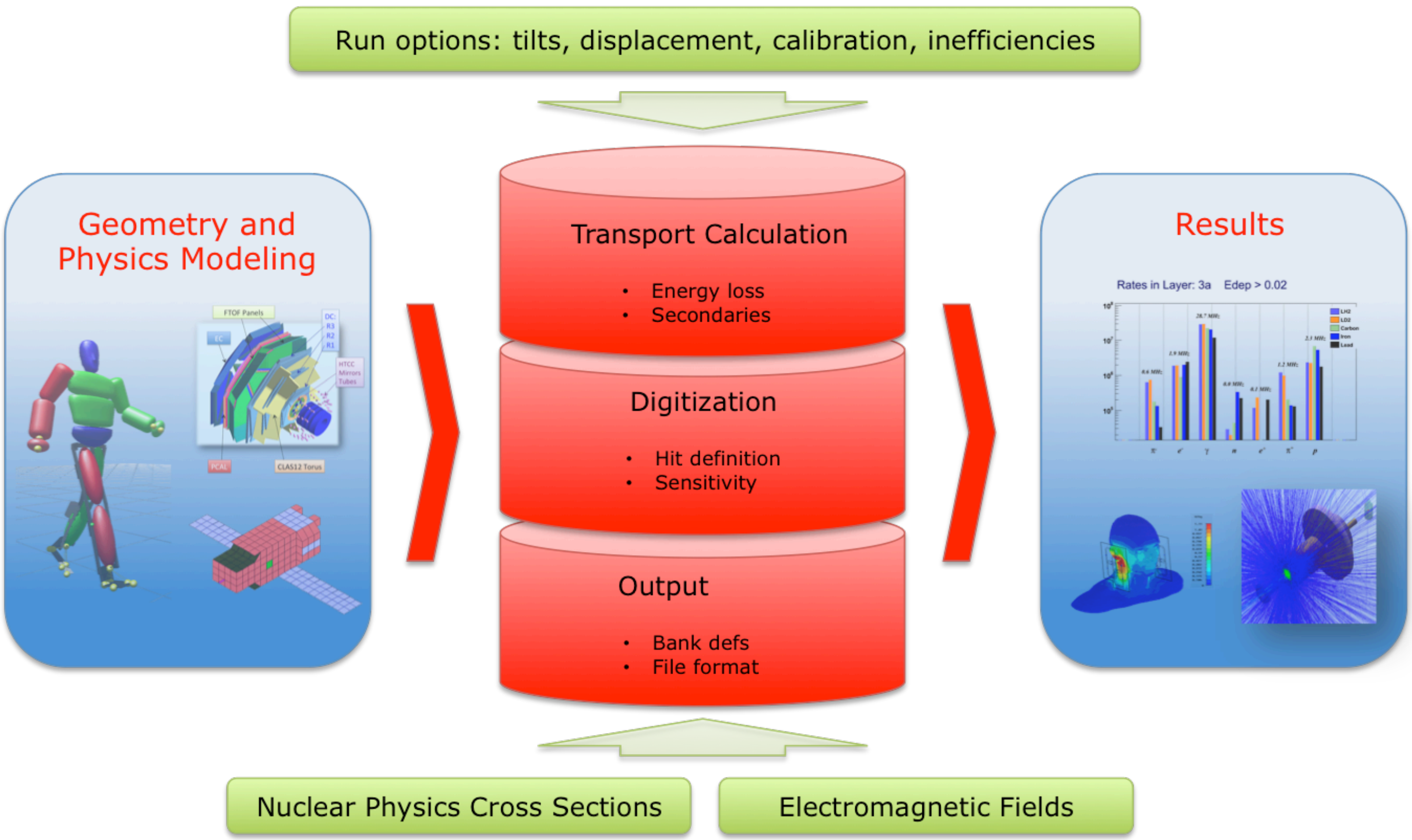


32 GeV π^+ tracks at $\eta=3.0$:



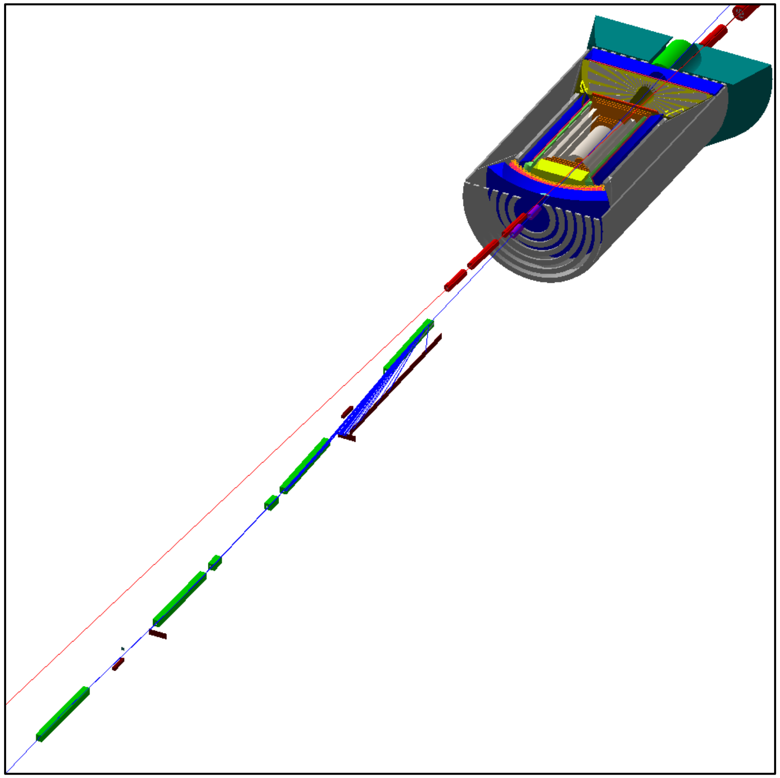
Fast Monte Carlo Productions

- JLEIC detector and physics simulations based on **GEMC**
- **GEMC**: framework for the Geant4 toolkit (C++), developed by Maurizio Ungaro (JLab)
- simulation of simple and full featured detectors (including estimated detector responses)
- fast running mode will full detector acceptance for physics simulations

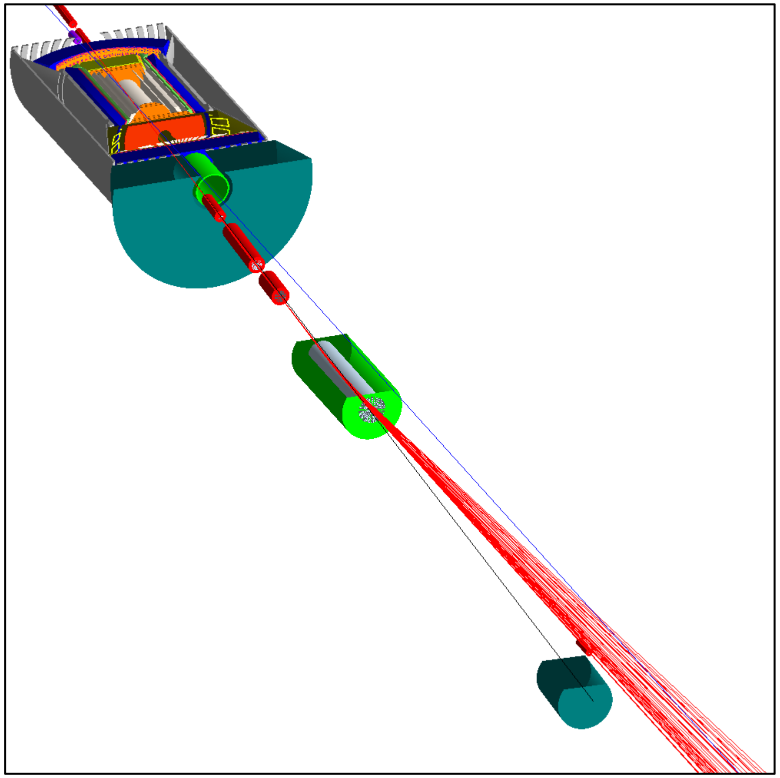


Example for GEMC simulations

Electron Downstream View

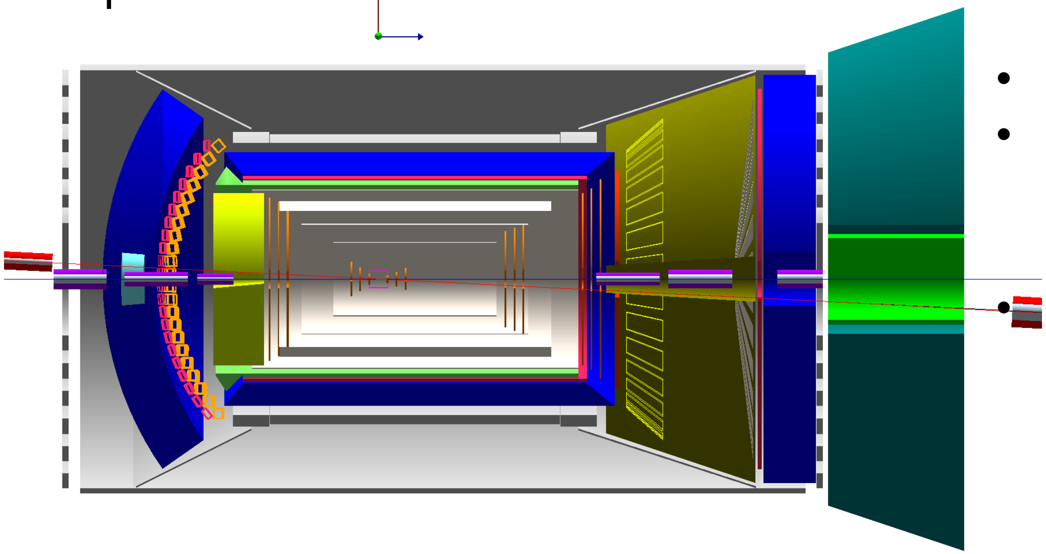


Ion Downstream View



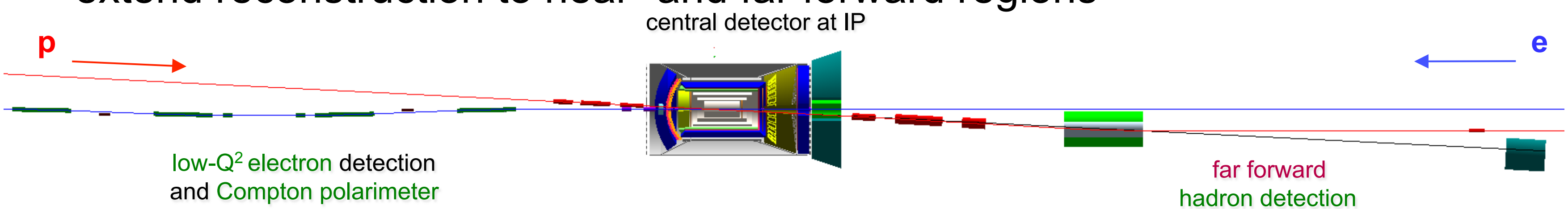
Towards a full track reconstruction

- implement full track reconstruction in the central detector:



- using all subsystems
- realistic layout of support structures, cooling, and other *dead* material
- base track reconstruction on GENFIT generic track reconstruction toolkit by FAIR

- validate the resolution of single tracks in the central detector
- study the impact of secondaries and random backgrounds
- extend reconstruction to near- and far forward regions



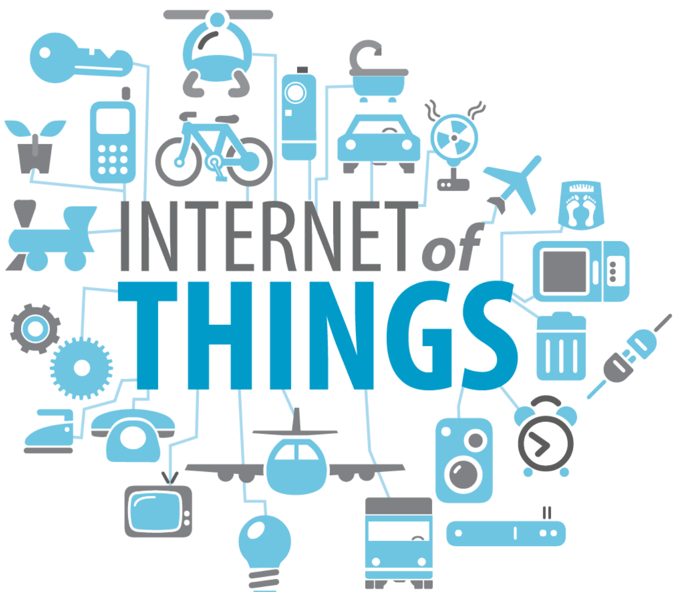
- develop a full reconstruction code for analysis of EIC data

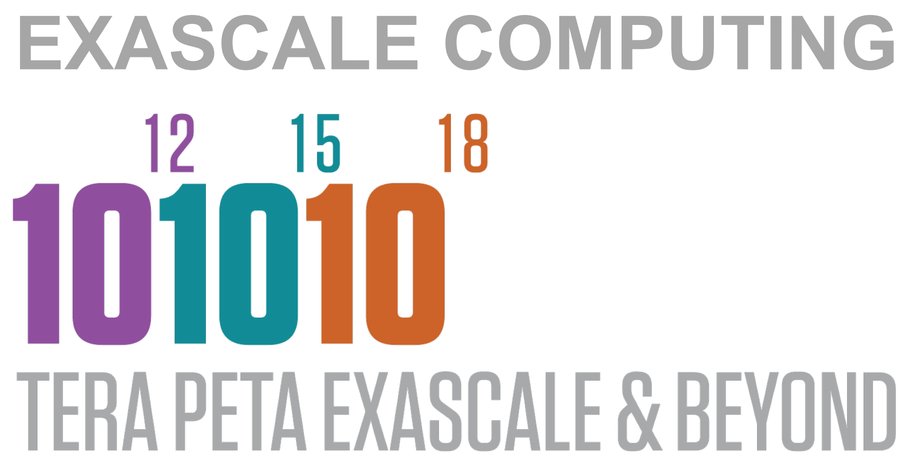
Future Trends in NP Computing

- high interest in NP / HEP community in the future of computing
- DOE Office of Advanced Scientific Computing Research works towards:
  - **Super Computing at the Exascale** (ANL, LB(N)L, ORNL)
  - **Big Data** and powerful computing
- time scale of EIC project allows for major improvements:
  - incorporate computing trends
  - but no change for change's sake
  - possible improvements:
    - improved usability to enhance productivity
    - significantly faster data (re)processing and analysis
    - better integration of good practices in analysis workflows, e.g., data preservation
- **workshop** to collect innovative ideas and to identify common goals:

March 16th – 18th at Jefferson Lab
website: https://www.jlab.org/conferences/trends2016/

Computing trends





Big Data - A possible paradigm shift for NP / HEP?

- **Big Data** is not about size

- **Big Data** is about the ability to quickly analyze large amounts of data. i.e.
    - have all raw and processed data permanently stored
    - in a scaleable random access storage
    - with fast, efficient data indexing (lookup) capabilities
        - resulting in a) more efficient use of computational resources (CPU) and b) fast data (re)processing and analysis

- **NoSQL** (non-relational) databases:
    - more flexible
    - better scaleable than traditional, relational databases
    - e.g., a graph database (e.g., used by Facebook)

- **R&D project:**
    - combine data of various SIDIS experiments
    - in a graph database
    - extract observables for TMDs
    - exploring modern data science methods
    - perhaps taking advantage of supercomputing

Exascale-2025

- Advanced Scientific Computing Research (ASCR) and NNSA Exascale
  - Build and deploy an Exascale Machine by 2025-27
  - Significant challenges: Parallel R&D paths
  - ‘prototype’ machines at 100 petaflops and 300 petaflops
- Scientific codes have to be developed
  - Intense development on underlying applied math libraries
  - Development of multi-scale simulations
  - “In Situ” visualization and data analysis
- Workflows to support simultaneous simulations and experimental data analysis
  - Seamless Integration of different scale hardware resources
  - Seamless Integration of research data management
- Fully funded, Project-like structure. Labs are being contacted for input
  - White papers requested: 240 received.
  - Exascale ‘Requirements Reviews’ with other offices: NP in June
  - ‘Applications’ area lead is gathering priorities

Computing in the Exascale Era

- **Exascale Computing - not just exaflops:**
  - exceptional degree of parallelism far beyond the capabilities of the Grid
  - rack-size pentascale computing

- **Exascale Computing at the EIC:**
  - integrate computing at accelerator / detector as it has never done before
  - Lattice QCD in the Exascale era
  - multi-scale multi accelerator / physics modeling
  - highly parallelized track finding algorithms
  - machine learning for automated detector calibrations and data validation

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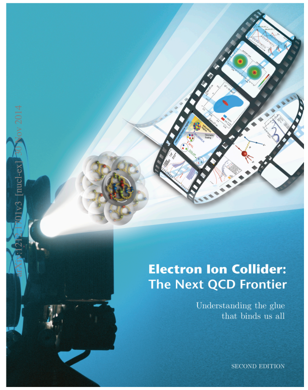

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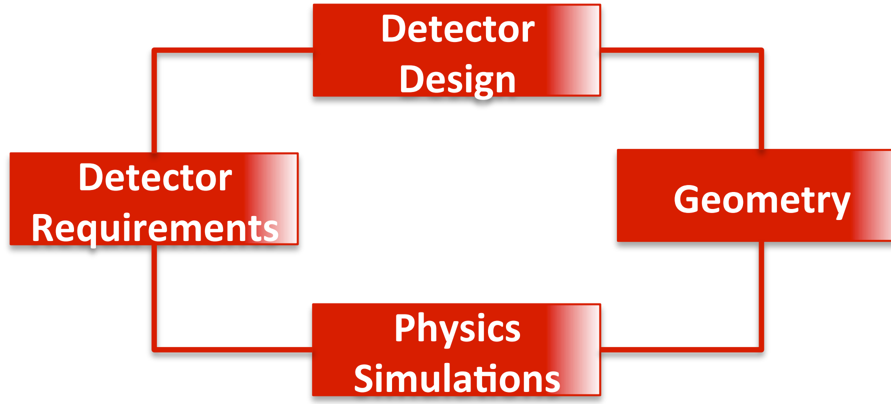

status reviewed in 09/15 workshop

active collaboration, **R&D consortium** being formed

active participation by you very welcome

Online & Offline Framework

collect first ideas

Workshop: Future Trends in NP Computing